Polarization Studies Group Newsletter

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News from the Advanced Photon Source XOR 4

Application deadline for beamtime is **March 17** for May-August trimester in 2004. If you are interested in applying for some beamtime, or developing a collaboration with sector 4 staff, visit Advanced Photon Source website www.aps.anl.gov, or contact Polarization Studies Group (of XFD) leader, George Srajer, at srajerg@aps.anl.gov.

Research Highlights

In this issue we present results of two experiments which take full advantage of polarization and general diffraction capabilities available at sector 4. First, a domain resolved magnetization reversal in artificial nanodot arrays was observed using soft x-ray resonant magnetic scattering. The second experiment, done on 4-ID-D, employed a depth-sensitive grazing-incident diffraction technique to study the local structure of amorphous SiO_2 at the Si-SiO_2 interface.

Domain Resolved Magnetization Reversal for Nanomagnet Arrays

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Fundamental changes in the statics and the dynamics of magnetization reversal in periodic nanostructures enrich the physics of nanomagnetism. However, as rather well-defined but non-single magnetic domains (or domain states) form in complicated geometries, it becomes difficult to characterize precisely magnetization reversal involving each domain at small-length scales with either conventional magnetization loop measurements, such as MOKE magnetometry, or MFM microscopy. Moreover, in large-area arrays typically covering areas of a few square millimeters, extracting overall domain structures during reversal from microscopic images is clearly unreliable. Such quantitative information is available using the technique of soft x-ray resonant magnetic scatteing (SXRMS). This technique exploits the strong enhancement of the magnetic sensitivity of scattering intensities when incident circularly polarized soft x-rays are tuned to an absorption edge of constituent magnetic atoms. Here we present a simple scheme to extract quantitatively domain-specific magnetization reversal for nanomagnet arrays by measuring rocking curves (Fig. 1). In order to obtain magnetic information, SXRMS peak intensities were measured by varying the applied field at different diffraction orders, whose scattering structure factors are different (Fig. 2). This allows us to determine directly the magnetization reversal of each magnetic domain using a simple linear algebra.

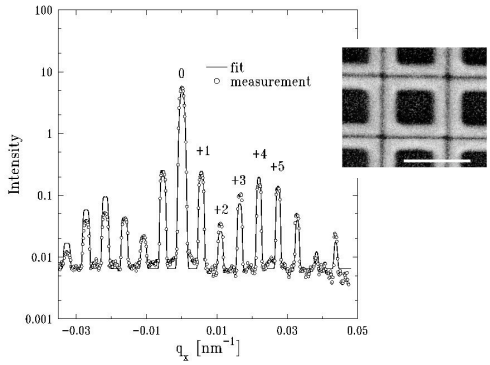

Figure 1: Scan along the q_x direction at q_z = 0.955 nm^{-1} from a square ring array at the Ni L_3 absorption edge (853 eV). Circles: measurements, and lines: calculations. Inset: SEM image of the array (bar = 1 μm)

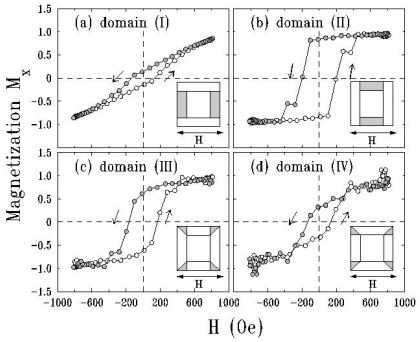

Figure 2: Extracted magnetization reversals along the field direction of four types of characteristic domains, which are depicted as gray-filled regions in the insets, from SXRMS hysteresis loops at zeroth-, first-, third-, and fifth-order peaks, respectively.

Modulation of the amorphous structure factor of thin SiO_2/Si(001)

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We take advantage of the high flux available at the Advanced Photon Source (APS) to study, in grazing-incidence diffraction (GID) geometry, the amorphous structure factor of thin SiO_2 (100, 500 Å). Tetrahedral units that constitute the SiO_2 are expected to accommodate, over the crystalline silicon template, and thus yield changes in position and intensity of the first sharp diffraction peak (FSDP; a prominent feature in vitreous glass that in the bulk normally appears at Q ≈ 1.5 $Å^{-1}$). Fig. 1 shows that effect in a reciprocal space map, {HK0}, presented in the Si crystal notation (100 Å film). The FSDP traces a semi-ring, with enhanced intensity at the Si(110) positions (whose reflections are forbidden by symmetry) , *i.e.* at Q ≈ 1.6 $Å^{-1}$. The remaining trace of the FSDP, with reduced intensity, appears at Q ≈ 1.4 $Å^{-1}$. The depth-dependence was investigated through analyzing a 500 Å SiO_2 film. With the aid of a position sensitive detector, data (FSDP positions) from the first 100 Å depth (Fig. 2), and down to the interface with bulk Si (Fig. 3), were simultaneously collected. There is no azimuthal dependence in the top-most region (Fig. 2), while close to the substrate a four-fold behaviour is clear (Fig. 3), with smaller Q variation than in the 100 Å film. At $\phi \approx 110°$ we have the $Si<\bar{1}10>$ direction, and at $\phi \approx 20°$ the $Si<110>$. Additional crystal truncation rod (CTR) measurements yielded a crystalline peak accompanied by Laue oscillations (with a period matching the film thickness). A fit to the CTR helped us to reconcile all findings through the inclusion of a sparsely distributed, and distorted, crystalline phase of SiO_2 (pseudo-coesite), Fig. 4.